

April 26, 2012

TO: Locust Hill Citizens Association

FROM: Joseph Cutro, P.E., Traffic Engineering Consultant

SUBJECT: Assessment of Proposed Auxiliary Through Lane, MD 355/Cedar Lane

### Overview

Per your request, I have performed an independent traffic engineering assessment of an “auxiliary through lane” planned for construction on northbound MD 355 (Rockville Pike) north of W. Cedar Lane/Cedar Lane in Bethesda. The project, as proposed by the Maryland State Highway Administration (SHA), is intended to provide additional traffic capacity through the MD 355/W. Cedar Lane/Cedar Lane intersection. This assessment is based largely upon my review of pertinent public agency documents, particularly those used by the SHA to justify the project, as well as a meeting with SHA staff on March 27, 2012. In addition, I have conducted runs of the program *Synchro*, the same capacity analysis tool used by the SHA, to determine the sensitivity of analysis results in response to changes in selected data inputs.

As a result of this examination, I have concluded that only under particular circumstances – the removal of the traffic signal at MD 355 and North Wood Road – could a northbound auxiliary through lane provide any capacity benefit at the MD 355/Cedar Lane (as named for brevity’s sake throughout this report) intersection. Such a benefit would be slight, confined to evening weekday peak hours only, and would likely be more than offset by coincident safety impacts along with physical impacts to the western edge of your neighborhood. Conversely, retention of the traffic signal at MD 355/North Wood Road, apparently a highly likely scenario, would leave the auxiliary through lane with no value of any kind. It is my recommendation to all interested agencies, including the SHA and the U.S. Department of Defense, that the northbound auxiliary through lane not be built, and dropped from further consideration as a congestion reduction strategy for the MD 355/Cedar Lane intersection. Funding for Phase 4 of the project should be re-directed toward more effective and appropriate traffic flow enhancements within the MD 355/Cedar Lane project area.

### Background

The 2005 Base Realignment and Closure (BRAC) law mandated the establishment of the consolidated Walter Reed National Military Medical Center on the campus of the former National Naval Medical Center in Bethesda. To help mitigate the additional traffic demand generated by the consolidation, the SHA has proposed major improvements at five intersections in the vicinity, including the MD 355/Cedar Lane intersection, its highest priority among those locations. The auxiliary through lane under consideration herein is the main element in the fourth and final phase of a multi-stage package of improvements planned for the intersection.

“Phase 4” of the intersection project is composed mainly of widening MD 355 north of Cedar Lane to accommodate an additional travel lane as far north as Locust Hill Road, and a convergence taper north of that residential side street. This phase also entails the conversion of a northbound right turn lane, to be constructed under project Phases 1-3, into a combination lane carrying both right turns (to northeastbound Cedar Lane) and through movements. The current estimated price tag for Phase 4 is \$11.8 million, that high cost being driven primarily by the need to construct retaining walls to address a bifurcation between northbound MD 355 and a parallel service road. Phase 4 would also entail a new sidewalk parallel to Rockville Pike north of Cedar Lane.

A major consideration in examining the value of a northbound auxiliary through lane is the presence of a traffic signal at the intersection of MD 355 and North Wood Road, the next intersection/signal immediately south (700 feet) of the MD 355/Cedar Lane intersection. North Wood Road serves as a primary access point to/from the Walter Reed campus. The signal was installed only in August, 2011, after the SHA’s original capacity analysis for the MD 355/Cedar Lane intersection had already been completed. Under current SHA plans, the future of the signal would be addressed in 2014-15, presumably after commitment of funding for the auxiliary through lane.

### Design and Operation

The total length of the proposed auxiliary through lane, beginning at the North Wood Road egress of the Walter Reed campus and ending at Locust Hill Road, is 1600 feet, including 700 feet of full-width (11-12’) widening north of Cedar Lane. An additional convergence taper length of nearly 700’ extends north from Locust Hill Road.

The widening and taper north of Cedar Lane appear to exceed all geometric requirements of the American Association of State Highway and Transportation Officials (AASHTO), and as such, can be regarded as a “safe” in terms of compliance with appropriate design standards. I do not believe that the hillcrest on MD 355 north of Locust Hill Road should obstruct sight lines or otherwise impede merging activity at prevailing speeds on Rockville Pike. More troublesome in my mind is the presence of an intersecting side road, Locust Hill Road, in the heart of the effective merge area. This will be discussed further under the “Safety” heading of this report.

Operationally, merging from the auxiliary lane should take place more-or-less evenly over the length of the lane and taper north of Cedar Lane, as gaps in the adjacent through lane allow. Under peak traffic flows, however, gaps in the adjacent lane will be fewer and changing lanes will become more difficult. Merging will tend to occur further northward, near the Locust Hill intersection and in the taper length north of that intersection. This concentration of merge activity will heighten safety risk for both the (new) merge itself as well as for (existing) turning movements at the MD 355/Locust Hill Road intersection.

Delay/capacity/congestion Benefits

I have examined the SHA's capacity analysis of the MD 355/Cedar Lane intersection in considerable detail and a number of flaws have come to light.

The SHA's apparently sole justification for constructing a northbound auxiliary through lane is a claimed reduction in "average control delay" or delay per vehicle entering the MD 355/Cedar Lane intersection. Based on 2006-2007 traffic counts extrapolated to reflect the BRAC consolidation, the SHA computed (using the *Synchro* capacity analysis program) a delay reduction of 8.6 per vehicle in the AM peak hour, and 8.5 seconds per vehicle in the PM peak hour. Reductions in delay can be translated directly into improved "Level of Service" – the more well-known rating of volume/capacity ratio and, up to a point, traffic congestion.

One error that was found in the SHA analysis was an incorrect application of signal control to the right turn on the eastbound approach of W. Cedar Lane. This error occurred only in the Phase 1-3 "before" analysis for the PM peak hour. Using corrected input, my re-analysis (also using *Synchro*) showed a loss of 2.1 seconds in delay reduction for Phase 4 of the project, a benefit that correctly belongs to Phase 1-3. The result is that the reduction in average control delay claimed for Phase 4 should be less than 7 seconds per vehicle in the PM peak hour. SHA staff has recognized the underlying error, and has agreed to incorporate the corrected input into its next round of intersection analysis (to be based on more recent post-BRAC traffic counts).

The key flaw, however, in the SHA's capacity analysis is the selection of an overly generous Lane Utilization Factor, or " $f_{LU}$ " as abbreviated by the nationally recognized *Highway Capacity Manual*. For a conventional 4-lane intersection approach feeding four downstream lanes that continue indefinitely, an assumed  $f_{LU}$  of 0.86 is consistent with *Highway Capacity Manual* guidance. However, further guidance from the FHWA publication *Signalized Intersections: Informational Guide*, recommends the use of lane utilization factors of between 0.73 and 0.82 for a 4-lane intersection approach incorporating an auxiliary through lane, in which the fourth lane is picked up approaching the intersection and is then dropped downstream of it. These reduced factors reflect the reluctance of drivers to shift lanes on the approach, only to have to merge back again beyond the intersection.

For the northbound approach of MD 355 at Cedar Lane, the SHA analysis has assumed a factor of 0.86 for its auxiliary lane scenario in both the morning and evening peak hours. SHA staff has stated that this "default"  $f_{LU}$  is justified because the auxiliary through lane is being fed directly from North Wood Road (on the Walter Reed campus) in a single-lane right turn movement. This justification, however, is valid only during periods when right-turning traffic from Wood Road constitutes a high percentage (20 % or more) of all northbound Rockville Pike traffic approaching Cedar Lane, and that traffic turning from North Wood Lane is effectively confined to only the auxiliary lane.

For the evening peak period, available traffic counts at the MD 355/North Wood Road intersection show that from 3 PM to 6 PM, right turn volume from North Wood exceeded 500 vehicles per hour. That is the estimated level needed to ensure sufficient utilization of the MD

355 auxiliary lane approaching Cedar Lane. Assuming that right turns are confined to the auxiliary lane [a very key assumption],  $f_{LU} = 0.86$  is valid during those three hours. After 6 PM, right-turning volume falls to less than 250 per hour, a level at which the auxiliary lane would be underutilized by through movements. While traffic counts for the MD 355/North Wood Road intersection are not currently available for hours outside of 3 to 7 PM weekdays, informal observations suggest much lower volumes departing the Walter Reed site during all other hours of the day (and week). This significantly includes the AM peak hour for local traffic. With so little traffic feeding the auxiliary lane during that hour, it would appear that the SHA's use of  $f_{LU} = 0.86$  in its AM peak hour analysis is invalid. Applying a more realistic factor of 0.76 for that period, the SHA's claimed reduction of 8.6 seconds completely disappears. So for the AM peak hour, a northbound auxiliary through lane would actually provide NO improvement in delay, congestion or capacity at the MD 355/Cedar Lane intersection. This would be regardless of the form of traffic control at the North Wood Road egress to MD 355.

An even more important factor affecting the performance of the auxiliary lane is the method of control for traffic turning right from North Wood Road onto northbound Rockville Pike. In its analysis for MD 355/Cedar Lane, the SHA has assumed that traffic departs Wood Road in a single-lane free right turn. Today's reality, however, at least for the evening peak period, is a triple right turn movement controlled by the traffic signal installed last year. If the traffic signal/triple right turn remains in place after Phase 4 is constructed, the auxiliary lane would be utilized by little more than right turns heading for northeastbound Cedar Lane. Given a choice of departure lanes, motorists leaving Walter Reed will avoid the merge conflict/delay that awaits them if they enter the auxiliary lane. The appropriate  $f_{LU}$  for the northbound MD 355 approach at Cedar Lane would be no more than about 0.76. My *Synchro* analysis run using this factor resulted in a 10.8 second **increase** in average control delay at the intersection, indicating a decline in performance, that is, a worsening of congestion. Such a theoretical decline would most likely manifest itself as unnecessary impedance to northbound right turns by through vehicles in the auxiliary lane. More significant, however, is that with traffic signal control at MD 355/North Wood Lane, the auxiliary lane north of Cedar Lane would become not much more than an unnecessary acceleration lane for right turns originating on westbound Cedar Lane.

To further examine the effects of retaining a traffic signal at MD 355/North Wood Road, additional *Synchro* runs were made for the PM peak hour. These runs were intended to identify the  $f_{LU}$  at which the average control delay at the MD 355/Cedar Lane intersection would be *unchanged* by construction of a northbound auxiliary through lane. This sensitivity analysis revealed the "break-even"  $f_{LU}$  to be 0.80. In other words, at any  $f_{LU}$  of 0.80 or less, an auxiliary through lane would have no delay/congestion/capacity benefit. The upshot here is that even if the traffic signal at MD 355/North Wood Road is removed, it wouldn't take much of a change in local traffic patterns (e.g., circulation alterations on the nearby institutional campuses) to render the auxiliary through lane useless.

### Safety

As reported to me, SHA staff has performed no quantitative analysis of the possible safety impacts of the auxiliary through lane. State staff has indicated that the introduction of sideswipe

crashes due to merging from the auxiliary lane would be offset by a reduction in more serious rear-end crashes on the northbound approach to the Cedar Lane intersection – a safety “wash” so to speak. While resource limitations do not permit me to provide a quantitative safety analysis of my own, I will address the conflict types recognized in the SHA’s qualitative assessment, as well as a number of conflict types that may not have been considered.

The addition of auxiliary through lanes, even when they do work to relieve congestion, tends to violate one of the basic rules of safe intersection design by expanding pavement area and providing the opportunity for additional conflicts. In this case, a significant new hazard type would be introduced, a sideswipe conflict stemming from vehicles merging from the auxiliary lane into the adjacent through lane of northbound MD 355. While it is generally true that sideswipes are less serious than rear-end crashes, the particulars of this situation might suggest otherwise. The proposed introduction of a roadside concrete barrier to protect pedestrians (from vehicles deflected in sideswipe crashes?) should raise some questions about the expected severity of these crashes. On top of that, the barrier itself could conceivably contribute to the further severity and complexity of these crashes.

In addition, a number of existing conflicts would be exacerbated:

- a rear-end hazard on northbound MD 355 approaching Locust Hill Road. Motorists in the auxiliary lane, while seeking “mergeable” traffic gaps in the adjacent through lane, would have to simultaneously look out for vehicles slowing to turn right into Locust Hill Road. The rear-end aspect of the conflict exists today, but it is not compounded by the additional merge task to be imposed on the trailing motorist. Some additional rear-end crashes should be expected.
- right-angle conflicts for vehicles turning left from southbound Rockville Pike into Locust Hill Road, and from Locust Hill Road to southbound Rockville Pike. These movements will be subject to 12 additional feet and about 1.0 additional second of conflict exposure, which will necessitate waiting for longer gaps in opposing high-speed traffic. Acceptable gaps in Rockville Pike traffic are already at a premium at certain times of day, and crossing motorists may take more risks than previously. The aforementioned concrete barrier proposal could also come into play here, and care will have to be taken to make sure that the barrier does not obstruct the sight lines of motorists departing Locust Hill Road.
- a sideswipe-weave conflict in the northbound auxiliary lane between North Wood Road and Cedar Lane. Worsening of this conflict would not result from construction of Phase 4 directly, but rather due to the removal of the MD 355/North Wood signal should that occur. Even without Phase 4, this conflict will exist within the Phase 1-3 configuration during hours when the signal does not operate.

I would agree that the improvements planned for the MD 355/Cedar Lane in Phases 1-3 should reduce rear-end conflicts in a major way. The correlation between approach delay and rear-end crash risk is well known, and a reduction in delay should result in a reduction in rear-end crashes. The problem that I have with the SHA’s “wash” assessment is that it implicitly assigns far too much crash reduction credit to Phase 4. Phase 4’s best-case potential for reducing rear-

end crashes would be commensurate with its delay reduction – slight and then only during a few hours of the day. For most of the other conflicts described above, and particularly for the merge conflict north of Cedar Lane, crashes can be expected on a 24-7 basis.

Overall, the total number of vehicle crashes with the auxiliary through lane would be much greater than without it. And for this particular case, I cannot concede that new sideswipe crashes would be less severe than the (very few) rear-end crashes replaced. It is therefore my opinion that the safety downside of this particular auxiliary through lane would virtually overwhelm offsetting safety benefits, if any.

### Cost-effectiveness

Information contained on pages 8 of the SHA's grant proposal to the Department of Defense can be used to derive a comparative cost-benefit analysis for Phase 4 of the proposed MD 355/Cedar Lane improvement project.

As stated previously, the primary benefits claimed for the Phase 4 are an 8.6 second improvement in average intersection delay in the AM peak hour, and an 8.5 second delay improvement in the PM peak hour. Under my analyses, these figures should be revised to zero and 7.0 (+/-) seconds respectively. Delay reductions of similar range (5-10 seconds) would apply to two additional hours on weekday evenings. Overall, however, modest delay reductions would occur in only about 15 out of 168 weekly hours, and that would be only if the MD 355/North Wood Road signal is de-activated.

As for costs, the SHA estimates for design, land acquisition, and construction are \$36.3 million for Phases 1-3, and \$11.8 million for Phase 4. For both phase groupings, I have assumed that 80% of funds are devoted to "congestion reduction strategies", while the remaining 20% are directed toward non-vehicular amenities like sidewalks and corner ramps.

The safety impacts of the auxiliary through lane, while not quantified at this time, are real and are certainly a negative in the cost-benefit balance sheet for Phase 4. Similarly, physical impacts upon the fabric and landscape of the adjacent Locust Hill neighborhood must be considered, most notably the replacement of a wooded hillside with a retaining wall along the neighborhood's western edge. Again these disbenefits can't be quantified here, but must be recognized as a further cost in determining this project's value.

Even discounting safety and neighborhood impacts, the cost-effectiveness of the current Phase 4 is extremely poor compared to Phases 1-3. Looking at the PM peak hour, the cost to improve average control delay at the MD 355/Cedar intersection would be \$268,000 per second for Phases 1-3. For Phase 4 (assuming the MD 355/N. Wood Road signal is removed), that cost escalates to \$1.35 million per second, a fivefold increase. As for the AM peak hour, the delay benefit in building the auxiliary through lane would be (less than or equal to) zero. This yields a cost-benefit ratio that is theoretically infinite, or more likely negative, i.e., spending money just to make things worse. Should the MD 355/Wood Road signal remain in place, the cost-benefit ratio for the auxiliary through lane would go infinite/negative in the PM peak hour as well.

The cost of the current Phase 4 is also way out of line with solutions that typically provide the same level of delay benefit. Per-vehicle delay reductions in the 5-10 second range are what might be expected from, for example, signal phasing or detection modifications costing in the range of \$50,000 to \$100,000 for a full intersection. In that light, a cost-benefit rate of \$1.35 million per second of delay should be regarded as extraordinarily high, particularly given plentiful signalized intersection examples where similar delay improvements have been achieved at a cost of only about \$10,000 per second. [This is not to say that a signal improvement could be effective at this particular intersection either now or after the completion of Phases 1-3. The fact is that, at many intersections, incremental signal modification remedies eventually become exhausted, and no further delay improvement is possible. The MD 355/Cedar intersection probably reached that state (at which further signal improvements do no good) long ago.]

In any event, Phase 4 as currently planned is a very poor value under the “best” of circumstances - with the signal at MD 355/North Wood Road taken out of service. And under conditions seemingly more likely to occur – the aforementioned signal remaining in place – the auxiliary through lane would appear to be a total waste of taxpayer dollars.

#### Conclusions and Recommendations

*Assuming retention of the traffic signal at MD 355/North Wood Road*, construction of an auxiliary through lane would result in no performance improvement whatever at the MD 355/Cedar Lane intersection, and could in fact, result in a decline in performance.

*Assuming de-activation of the traffic signal at MD 355/North Wood Road*, construction of a northbound auxiliary through lane at MD 355/Cedar Lane could result in a slight reduction, about 7 seconds per vehicle, in average control delay at the latter intersection from 3:00 PM to 6:00 PM on weekdays.

*Assuming either de-activation or retention of the traffic signal at MD 355/North Wood Road*, construction of an auxiliary through lane would yield no delay/capacity improvement at the MD 355/Cedar Lane intersection during weekday morning peak hours.

Safety and physical (“environmental/aesthetic”) disbenefits have not been adequately considered in the SHA’s previous evaluation of this project.

The congestion relief value computed for the proposed auxiliary through lane is highly sensitive to values *assumed* for certain data inputs, most notably the approach Lane Utilization Factor. The SHA’s use of a “stock” value for  $f_{LU}$  in this case, essentially a guess, has lead to an invalid conclusion regarding the benefit of the proposed project.

Based on the foregoing, **the auxiliary through lane proposed for MD 355/Cedar Lane Phase 4 should not be built**. Instead, funding for Phase 4 should be re-directed toward more effective and appropriate traffic flow enhancements within the MD 355/Cedar Lane project area. There appears to be some promise, for example, to providing an additional (4<sup>th</sup>) lane on northbound

MD 355 between Wilson Drive and North Wood Road, particularly if the signal at North Wood Road remains in service. The SHA should investigate such an alternative.

More recent SHA traffic counts, in addition to assessing the actual impact of BRAC consolidation, will allow a new look at the SHA's earlier analytical conclusions as well as those drawn in this report. I recommend that both analyses be revisited when that data becomes available. Any new analyses should include a scenario entailing the future retention of the traffic signal at MD 355/North Wood Road.

The SHA and Department of Defense should consider an earlier resolution/decision to the MD 355/North Wood Road traffic signal issue, in advance of any decisions upon the content and funding of MD 355/Cedar Lane project Phase 4. In my opinion, that decision should favor retaining a traffic signal at the former location.